HAROLD MOWAT.

ETHYL CHLORIDE

AS A

GENERAL ANAESTHETIC.

M.D. THESIS.

Immediately after getting my M.B. degree, I obtained the post of House Surgeon to a Hospital in the South of England. One of my duties there was to administer anaesthetics. As a result of this I obtained a good experience in this branch of medicine, and plainly perceived that from it, my M.D. Thesis would be chosen.

Chloroform, which I was rightly taught to revere so highly in Edinburgh, did not occupy such a high position in my new abode, ether being considered the best anaesthetic for lengthy operations, while the palm for shorter anaesthesia was in turn wrenched from chloroform, and was given to a gas, about which I had only the smallest knowledge.

Ethyl Chloride. It was my privilege to administer this several hundreds of times, and noticing in the current medical literature, a controversy raging on this "new" gas, as it was considered by not a few, I published my small article in the "Lancet", and considered myself quite an authority on the subject. Since that time I have dipped into all the literature on Ethyl Chloride that I could lay hands on, in the Royal College of Surgeons library in Lincoln's Inn Fields, and beg to offer a full consideration of the gas for my thesis. In order that I may omit nothing of importance, I propose to cover the ground in regular order under the following headings:-

1. History.
2. Physical and Chemical characters.

3. Physiological action.

4. Modes of administration:-

Varieties of inhalers and flasks.

5. Preparation and position of Patient.

6. Normal action and accompanying phonomena.

7. Possible accompanying phonomena:-

After effects.

8. Death from gas - statistics and

Post-mortem appearances.

9. Indications for use.

10. As a preliminary to other anaesthetics.

11. Contrast with nitrous oxide and other

anaesthetics.

As regards the originality of my remarks, I may say that, with the exception of Clauses 1, 2, 3 and 8, and a few remarks which are immediately followed by a reference, the whole Essay is based on my own experiences, and is taken from my own observations.

Precise references will be given at the beginning of each of the sections referred to, to the publications from which I have obtained information.

H I S T O R Y

References: Internat. Clinis Philadelphia a1905, 111198-219.

Lancet 1905.11.1023-1027.

British Medical Journal 1903. June 20. 1421.

Ethyl chloride, also called aether chloratus, chlorathyl and hydrochloric ether, was first used in 1848, so that any claim that has been brought forward regarding its novelty may be at once dismissed. In that year Heyfelder first anaesthetised a patient for five minutes for the recovery of a seton. The after effects were vomiting and headache. The same Surgeon employed it secondly for Chopart's operation, and this time no after effects were observed. Commenting on the drug, Heyfelder wrote that it was "well borne, causes no cough, no difficulty in breathing, no increase in salivary and lachrymal secretion, and no injection of the conjunctiva". His complaint was the high price and volatility of the gas.

No one appears to have used ethyl chloride after this until 1867, when B. W. Richardson employed it, and stated that it was "good and safe".

The next mention of it was in 1895, when Carlson found that when used locally on the gums unconsciousness was produced. Immediately after this Thiesing and Billeter employed it as a general anaesthetic with good results.

In 1898 Lotheisen, of Innsbruck, published a paper on the narcosis of ethyl chloride; he appears to have been the first to have made a routine use of the drug in general surgery.

In 1901, McCardie, of Birmingham, who had previously translated and published Lotheisen's papers, stated his results. He was the first man in Great Britain to use the gas as a general anaesthetic; he waited till he had read the report of 2,500 cases of administration abroad before he gave the anaesthetic himself.

Immediately after this the gas became more general, and in 1904 and 1905 was greatly boomed. It was sold by Bengue, of Paris, as Narcotile; by Fries Bros., of New York as Askelene, and in this country largely as Somnoform, which is not the pure gas at all, but contains, of ethyl chloride 65 parts, of methyl chloride 30 parts, and of ethyl bromide 5 parts.

Every edition of the Medical Journals contained articles on the gas, one school lauding it to the skies as the best and safest of anaesthetics; another depreciating it as a most dangerous article; while a third school, the moderate one, probably right in this case, as in all others, maintained that in chosen cases, it was a good and useful anaesthetic, but that it was one not to be used without discrimination and intelligence.

From this turmoil, certain facts now stand forth; the boom is over, and ethyl chloride has taken as

yet an unstable position, as a most useful anaesthetic, but a position which is likely to fluctuate for some time, until it finally finds its fixed place among the other three great anaesthetics,- chloroform, ether, and nitrous oxide gas.

PHYSICAL AND CHEMICAL CHARACTERS

I will here give some of the most important characters of ethyl chloride, characters which have a practical bearing on our subject, and which can be obtained and verified in any large chemistry text book, such as Bloxam's or Watt's.

Ethyl chloride has the chemical formula C_2H_5Cl.

It is a colourless and mobile liquid, having a peculiar aromatic odour, and a sweetish taste.

The specific weight at 0°C is 0.9214.

At 8°C this decreases to 0.9176. It will therefore be seen that there is a marked increase of volume with increase of temperature. The density of the vapour, air being taken as unity, is 2.3, and it therefore follows that it will sink to the bottom of a bag of an inhaler, and remain there for some time.

In alcohol it is very soluble; in water it is only slightly.

It volatilises without any residue at ordinary temperature, volatility being a marked character of the gas.

The spray is much larger in hot weather than in cold; in frosty weather it is frequently impossible to get any spray from a flask until the nozzle has been placed in warm water.

The practical value of this point is that ethyl chloride should never be squirted from a flask into a bag without observing the quantity of

fluid sprayed, it being distinctly dangerous to gauge the amount by time.

It is very combustible, and when brought into contact with a light is decomposed, burning with a green edged flame, setting free hydrochloric acid gas.

There is no tendency for ethyl chloride to decompose, it being safe to keep it in the usual 60 C.C. flash for as long as eighteen months.

It is of practical interest to observe that the gas has no action on pure rubber. Several writers have complained that ethyl chloride has ruined the rubber of their anaesthetic bags, but there is no doubt that in such cases the fault lay in the quality of the rubber.

If a bag is not flushed with water frequently it will be found that the gas has frozen, and lies at the bottom in solid blocks of ice.

As regards purity, the best test is that of smell, the pure preparation having an agreeable aetherial odour. If the drug is allowed to evaporate in the hand any impurity is easily detected by its odour. It is an undoubted fact that some of the foreign brands have an unpleasant smell.

A pure preparation should have a neutral action, and should not redden tournesol paper, when the vapour has been introduced into water, nor form a precipitate if nitric acid, and a solution of silver nitrate, be added.

Ethyl chloride is prepared by saturating alcohol with hydrochloric acid gas, and distilling on a water bath. As a result of this ethyl chloride is disengaged, and should be passed first through a wash-bottle, and then through a tube containing calcium chloride, after which it may be condensed in a receiver placed in a freezing mixture.

Formula C2 H5 O H + HCL = C2 H5 Cl + H2 O.

PHYSIOLOGICAL ACTION

References: Bio-Chemical Journal, Liverpool 1906. 1. 328-340.

British Medical Journal 1903. 1421-1425.

International Clinics, Philadelphia, 1905. 111198-219.

Proceedings of the Royal Society, London, 1905-6. 86-102.

British Dental Journal 1903. 650.

Dental Cosmos, July 1892.

In the year 1880 the first tests with animals were made, in order to ascertain the physiological action of ethyl chloride.

Nothing apparently came of these experiments, immediate death following the exhibition of the drug.

In 1892 definite results were obtained by Professor H. C. Wood and Professor Cerna, experimenting on dogs. Ethyl chloride was administered by inhalation, and also by instillation into the jugular vein with a cannula. Anaesthesia lasted from twenty seconds to two minutes.

The observers stated that a large fall of blood pressure was registered; also that in 50% of the cases an increase of respiration was apparent.

The fall of blood pressure was attributed to too strong a vapour, acting on the laryngeal filaments of the vagus.

As a result of these observations ethyl chloride

was condemned as a dangerous anaesthetic because of its action on the heart.

In 1903, Cole, of Birmingham, published his results in the British Medical Journal.

In 1906, Webster, writing in the Bio-Chemical Journal, while agreeing with Cole on most points, formed opinions diametrically opposite to him in others, and it will best serve our purpose if we consider these two most important publications together.

Cole experimented with somnoform, which, as before stated, contains 65 parts of ethyl chloride, and in addition smaller proportions of methyl chloride and ethyl bromide.

Taking first the action on the <u>blood pressure</u>, he found that at the commencement of anaesthesia this was slightly raised, but was followed during deeper anaesthesia by a considerable fall. At the cessation of inhalation a large rise was observable. These results may be gauged with the finger on the radial pulse, for there is no action on the walls of the vessels themselves, their fullness being entirely dependent upon the pressure of the blood. Webster, who states that ethyl chloride, bromide, and iodide, as well as somnoform, all have practically the same physiological action, any differences being only of degree, and depending on the extent of the various volatilities, carried out his experiments on dogs, cats and frogs, and

gives his results as follows:-

In small doses, ethyl chloride causes a slight rise of blood pressure, soon followed by a return to the normal.

In larger doses there is a rapid fall of blood pressure, more pronounced after section of the vagi, and under the action of atropin. This fall may, or may not, be preceeded by a preliminary rise.

It will be seen by comparing these observations of Cole and Webster, that they are practically in agreement regarding the action on blood pressure. This fall of blood pressure is an undoubted danger in the administering of ethyl chloride, but it is not the chief one, respiratory failure being the great stumbling block.

Regarding the action of chloride of ethyl on the heart, both observers are agreed that there is a general diminution in the frequency, and extent, of the excursion of auricle and ventricle.

With increasing doses, the conduction of the ring becomes depressed, the ventricle beating half as frequently as the auricle.

These conclusions were arrived at with intact vagi. With the vagi cut, the heart beats less frequently, both the auricular and ventricular power being less. As to the cause of this, however, Cole and Webster are at variance, Cole, although he allows the possibility of the accelerator being stimulated, declaring that the vagal nerve ending is paralysed

by ethyl bromide. Webster, on the other hand, maintains, and his tracings show it to be so, that the vagal endings are not paralysed, but are, on the contrary, in some cases, even stimulated. Thus it is possible to obtain the full vagal action when an animal is completely under the anaesthetic.

The important practical point, regarding the action of the drug on the heart is, that although there is diminution in the heart's action, this danger is mitigated by the fact that the medullary centres do not become anaemic, and respiration does not cease until some time after the causation of complete insensibility, and therefore by artificial respiration it is easy to revive a patient suffering from heart failure under ethyl chloride.

Coming now to the action on <u>respiration</u>, all conclusions point to the fact that cessation of respiration is the great danger in ethyl chloride administration.

Cole has found that in small quantities respiration is stimulated, the action taking place especially on the diaphragm, the cerebral centre of which is stimulated. In large doses, tonic contractions may be brought on, and death result from respiratory failure, the heart continuing to beat until after death.

Webster states that small doses of the drug increase the rate and depth of respiration,

although sometimes the depth alone is increased, the frequency being unaltered. When inhalation ceases, normal respiration is once again reached. In larger doses, although there is again an increase of rate and depth, it is only transitory, and is followed by shallower and less frequent respiration.

In toxic doses, respiration ceases from 2 to 3½ minutes before the heart has ceased to beat. These phonomena, as before pointed out, take place because of the action on the respiratory centre, and occur before and after vagal section. Should the respiration cease for a short time, and again become established, its strength will be seen to increase steadily, beginning with shallow breaths of deepening volume.

Considering as a whole the action of ethyl chloride on the respiratory system, one cannot fail to come to the conclusion that it is the danger of asphyxia, and respiratory failure, that is the great cause of the timidity of many in using the gas, as a general anaesthetic.

Cole, in his article, as well as describing the action on the blood pressure, heart, and respiration, has investigated the changes on the muscular system. On skeletal muscle a rythmic movement of the ~~units~~ limbs and jaws takes place during anaesthesia, the tone of the muscles being firm. Struggling movements, which frequently are present, may be due to excitation

of the cord, or higher centres. Of non-skeletal muscles, the bladder of the cat has been investigated, where it is found that there may be a distinct rise of pressure.

Coming next to the action of the drug on the brain, one is bound to confess that the little known on this point is unsatisfactory.

Rolland experimented on animals, injecting methylene blue, making sections of the brain, and examining them under the microscope.

He states that as a result of this he found that the cells first affected are Purkinjes; owing to the action on these cells the sensibility to pain is surpressed.

The next cells to be affected during deeper anaesthesia are the pyramidal, the sense of touch being surpressed, and the loss of consciousness following.

Rolland describes these actions as "elective", and compares them to the elective action of muscarin on the ganglia of the heart. He also states that "moniliform" varicose, and irregular knotty conditions are observable in the filiform prolongations of the brain cells under the action of ethyl chloride.

When deeply under, owing to the action of the drug on the centres, in the brain and cord, athetotic movements of the muscles take place, the upper extremity being chiefly involved.

As a result of the stimulation of the medullary

centres, nausea results, but direct irritation of mucous, secreted under anaesthesia may be a cause of sickness.

As regards the action on other systems, it has been stated that jaundice may follow the administration of the drug. In prolonged anaesthesia albuminuria may be caused. Fatty degeneration of the kidneys and liver have been found.

In concluding this section, it will be instructive to investigate the manner in which the gas exercises its influence.

It is stated that anaesthetics form unstable compounds, or aggregates with proteids of tissue cells, and anaesthesia is due to paralysis of chemical activities of the protoplasm, as the result of the formation of such aggregations. These compounds are unstable, and remain formed only so long as the pressure of the anaesthetic in the blood is maintained.

A splitting off of electrodes accompanies this combination of anaesthetic with proteid.

MODES OF ADMINISTRATION - VARIETIES OF INHALERS AND FLASKS.

There are two methods by which chloride of ethyl may be administered, the open and the closed. I have tried both, and am bound to state that I have found the former unsatisfactory. The open method involves the free admission of air, both after anaesthesia is produced, and also during oncoming unconsciousness. An ordinary cone, such as is employed in chloroform administration, may be used in this method.

Some advocate keeping a patient under, during a prolonged operation, in this manner, but I think from the mere fact that ethyl chloride has the action described before, on the diaphragm and respiratory apparatus, there is nothing to encourage us to employ the drug for a long anaesthesia.

As regards the administration for a short period by this method, the difficulty that anyone will find in getting the patient under, when air is freely admitted, will warrant its non-use.

The true closed method means that after the patient has once inhaled the gas, he should breathe no air until the bag has been removed from his face, that the operation should then be undertaken, and no further gas exhibited.

This process has been modified by what has been called the "Semi-open" method, when a small

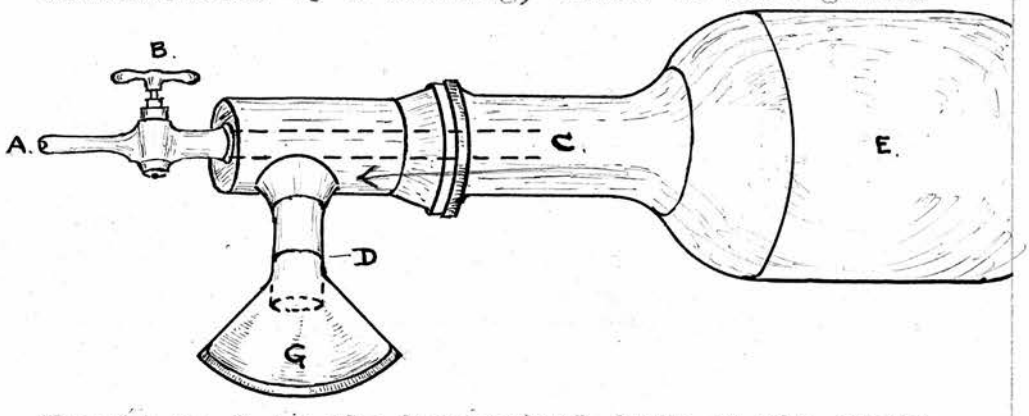
quantity of air from time to time is introduced with the gas into the bag of a closed inhaler. It has the advantage, according to some, of being safer while anaesthesia is being produced, a slight amount of air mixed with the gas, enabling a patient to more easily become anaesthetised. This I have never found.

The advisability of using ethyl chloride gas for any length of anaesthesia must always be a disputed point, and although I have kept a patient under for twenty five minutes with the semi-open method, I found the eye tests so irregular, that in spite of the fact that there was never any trouble with the breathing, I must confess that guess-work controlled my actions, and I have since hesitated to employ the gas in any but short operations. I therefore believe that the right method to give ethyl chloride by is the closed method, the gas being so irregular in its action, and so dangerous, that it has no advantage over ether or chloroform for prolonged operations.

As regards the <u>varieties of inhalers</u>, now-a-days there is a regular "Ethyl Chloride Inhaler" employed.

One of the best of this variety consists of a face-piece, a bag, and an angle mount, through which the fluid can be squirted. The face-piece and bag need no description, as they are the same as those of a Clover or Ormsby ether apparatus. The only point, which might be stated is that it

is better to have a light transparent face-piece, as then the face of a patient can be observed through it. One end of the angle-mount (horizontal limb) opens directly into the bag; the other side (vertical limb) is connected with the face-piece, so that the patient breathes the gas in the bag. Through the horizontal limb gas is squirted, through the angle-mount directly into the bag, a stop-cock being open. When the stop-cock is closed no air can penetrate. This is the ideal bag, and can be easily demonstrated by a drawing, which is here given:-



From A to C is the horizontal limb of the angle-mount.

D. is the vertical limb, to which G., the face-piece is attached.

B. is the stop-cock.

E. is the bag.

Ethyl chloride is squirted in at A., the stop-cock B. being open, and reached the bag E. at once. The arrow indicates the direction of the flow of gas from the bag to the patient's mouth.

The manner of administering the gas through this apparatus is very simple. The patient is told to

breathe quietly into the face-piece; heavy breathing is to be avoided, as then there is a difficulty in distinguishing this forced respiration from anaesthetic breathing, and also the patient feels uncomfortable, and may inhale an unnecessary amount of the gas suddenly, choking being the result.

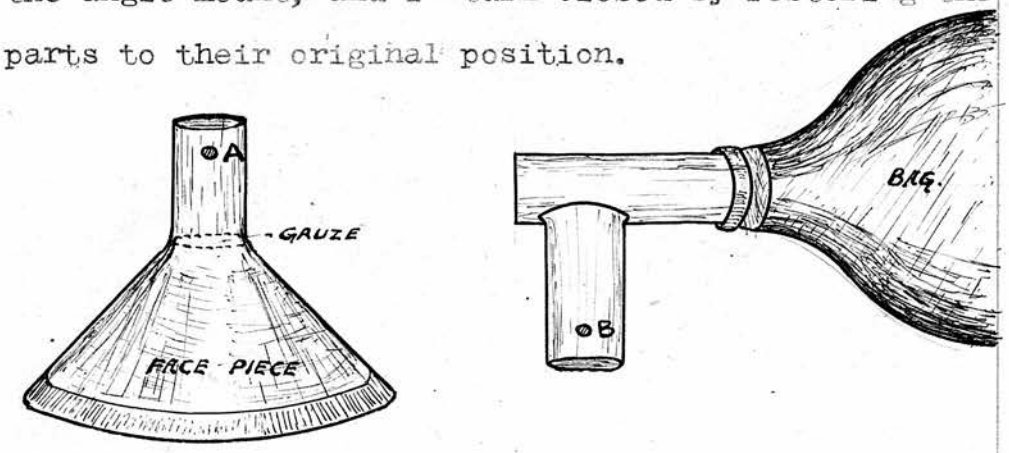
When by quiet breathing the bag has been blown out, the face-piece having been slightly raised from the mouth during inspiration, and replaced during expiration, the gas is squirted into the bag. Some advocate exhibiting the full amount at once, some in gradually squirting the fluid a little at a time, so that choking may be avoided.

I believe in the former method, having rarely been inconvenienced by the choking, and have lately filled the bag with, in children, according to age, ½ to 3 c.c.; in women 3 to 4 c.c.; in men 4 to 5 c.c. A larger dose in a very great percentage of cases is unnecessary, and dangerous. The face-piece is held firmly over the mouth until full anaesthesia is produced, the symptoms and stages of which will be shortly described, when it is removed, and the operation proceeded with.

I have reason to believe, asI stated in the Lancet, that if the full amount of ethyl chloride is exhibited at once the period of anaesthesia lasts slightly longer, and is more complete than that produced by gradually allowing the gas to be inhaled. Further, headache is avoided, as an

after effect, as the amount of gas inhaled is limited by this method.

When I first used ethyl chloride, I did not employ the inhaler above described, but one, the angle mount of which consisted of two pieces, the upper one being attached to the bag itself, the lower to the face-piece. A hole, through which the gas was squirted, was opened by rotating the upper half of the angle mount, and in turn closed by restoring the parts to their original position.



B., the upper piece, fitted over A., the lower, and was rotated till the two holes came together, when ethyl chloride could be squirted in.

One of the advantages of this apparatus was stated to be the ease with which ethyl chloride could be exhibited gradually in small quantities.

Its disadvantages were the trouble caused by the two parts of the angle mount imperfectly rotating, and sticking, the necessary admission of air during the production of anaesthesia, because the full amount could not be given at once, as the gas did not enter the bag at all, but was squirted through gauze into the face-piece.

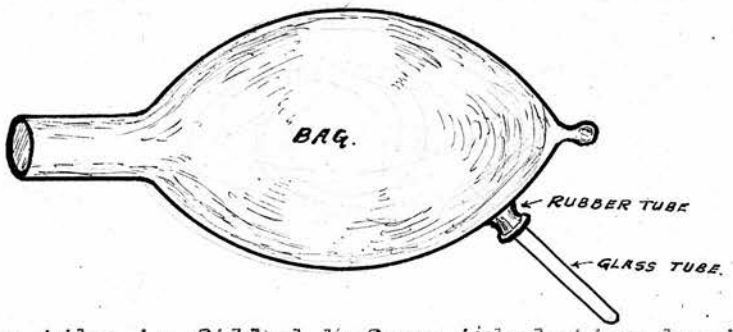
Some administrators fill their bags with ethyl

chloride, and then turn off the stop-cock, and carry the bag from room to room. For this a twoway stop-cock is necessary, which completely isolates the bag, and in addition allows the entrance of gas or air, according to the wish of the anaesthetist.

Many people do not trouble to procure a special bag at all, but employ with success the ordinary Ormsby, or Clover, ether bag.

Carter-Brain's modification of the Ormsby allows the spray to be squirted beyond the sponge into the bag, and to slowly soak through.

Another excellent inhaler has a small rubber tube, in communication with one side of the bag, to which a glass tube containing 5 c.c. of the gas is attached, and which can be tipped up, admitting just as much ethyl chloride as is required.



The glass tube is filled before inhalation begins, and is then attached to the rubber tube.

The advantage of this apparatus is the ease with which administration can be carried out during struggling, there being no necessity to have one hand employed with a flask.

This modification I have frequently used with a Clover, for the combined exhibition of ethyl

chloride and ether.

It is impossible for me here to describe every variety of inhaler that has been introduced within the last few years, but I wish to describe the latest inhaler yet produced, one suggested by Dr. Alexander Sharp, and made by Messrs Rauschke Ltd., of Leeds. A reference to it can be found in the Lancet, of March 23rd 1907, on page 817. Two diagrams will make the explanation clear.

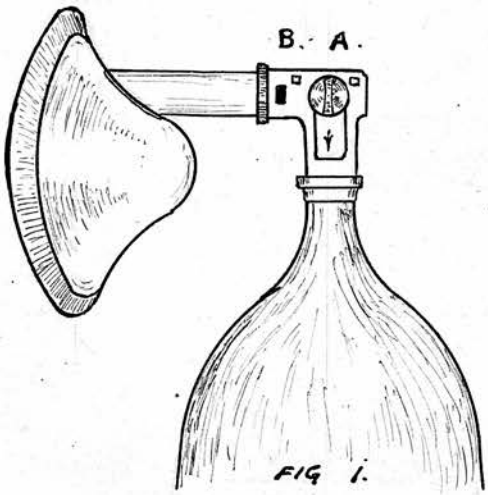


FIG I.

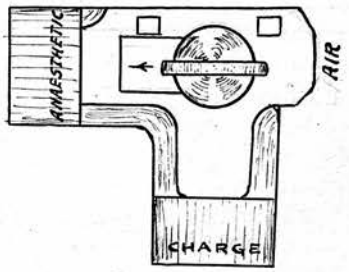


FIG II.

As seen by the illustrations (Figs. 1 and 2) a tap which regulates the administration of the anaesthetic is introduced between the face-piece and the bag. To charge the bag the tap is turned so that the indicator points to "Charge" and the ethyl chloride is injected through a small hole in the tap indicated at A in Fig. 1. The tap is then turned to "Air", thus securing the ethyl in the bag until quite ready to begin. With the tap in this position the face-piece is applied and the patient breathes air only which enters through the inlet seen in the side of the tap B in Fig. 1. At the beginning of an inspiration the tap is

turned so that the indicator points to "Anaesthetic" as seen in Fig. 2. This movement closes the air inlet and opens the communication between the face-piece and the bag. This inhaler is specially convenient when a few minutes continuous anaesthesia may be necessary, for without disturbing the face-piece air can be admitted to the patient, the anaesthetic can be shut off, and the bag can be recharged. The aseptic advantage of the improved face-piece will be evident. The face-piece being connected at its upper end instead of at its centre protects the other parts of the anaesthetic apparatus from contamination in the event of the patient spitting, coughing, or being sick. When desired the apparatus can be fitted to a Clover inhaler.

The varieties of flasks are three in number:-

1. Flute key flask.
2. Duncan & Flockhart's flask.
3. Reynolds & Branson's Anteolar.

To these main varieties many modifications, more or less unnecessary, have been added.

I have nearly always used Duncan & Flockhart's, which I consider undoubtedly the best. It contains 60 c.c. of ethyl chloride, and costs two shillings. The exit of the spray from it is easily controlled, and the gas can be injected accurately into the bag. These remarks do not apply to the Flute-key flasks, which for that very reason I consider of much less value.

PREPARATION AND POSITION OF PATIENT

Nearly all administrators, who have published the result of their experiences of ethyl chloride, have stated emphatically that careful preparation is essential, not only for safe anaesthesia, but also for the avoidance of ill after effects. Commonsense will teach us all to respect this fact, and although, if I were to instruct anyone in the administration of the gas, I should tell them all to prepare their patients, I am bound to confess that I have given chloride of ethyl frequently, in the out-patient department, with no ill results, and no ill after effects, to patients, who have not been prepared in the fashion one advises them to be. I refer to dental patients, who had come up for teeth extraction; some of them tired with a train journey, and walk from the country, who began the day with a good breakfast, "to keep up their strength", and who had never given a thought to their bowels the night before. Therefore, though in theory, I know that preparation is a necessity, practice has not always proved it to be so, and I cannot take the dogmatic view in this respect, which the majority insist on. I have always, however, with the exception just stated, told patients to prepare themselves for the anaesthetic, in the following manner:-

a. Take a purge the night before, and get a good action of the bowels in the morning before the operation takes place. The purge I recommend

is castor oil, as the majority of patients are children, but as regards adults, I do not know that this is preferable to other laxatives, as regards ethyl chloride anaesthesia.

In hospital it is an excellent plan to give an enema the evening before the operation.

b. No food must be taken within three hours of the operation. If it is to be in the morning, breakfast must be omitted; if later in the day a light fluid diet may be permitted three hours before.

As regards other points to be attended to immediately before the operation, loose clothing round the hips and neck, and removal of false teeth, are important preliminaries in this, as in all other anaesthesias.

There is one special point, however, which I have always observed, and which I consider most necessary, as in cases in which I have omitted to carry it out, I have suffered great inconvenience; I refer to the necessity of the insertion of something between the teeth, in order to avoid jaw fixation, in operations round the mouth.

In dental cases the prop is a necessity.

In tonsil and adenoid operations, I used to place a cork, attached to string, between the patients teeth, but lately, since I have used Doyen's gag, I have found this unnecessary, as this excellent gag can be placed in position before the anaesthetic is commenced, and turned round and opened when the

period of anaesthesia has begun.

And now as to position of the patient, again, experience has taught me to differ slightly from well recognised principles. Nearly everyone advocates the prone position, and condemns the sitting posture, but practice has proved to me, that there is no great danger in the latter. I have given the gas quite two hundred and fifty times to patients in the dental chair, and the only case of embarrassed breathing that I have observed, under these conditions, was one when the tongue was forced back by the prop, in which quiet breathing was restored by re-adjustment. I do not, however, advocate the sitting posture as the better, for there can be no possible doubt that the prone position is the ideal one, the large fall of blood pressure and heart depression which we have discussed, always being a possible danger of the former, but I believe that a great deal that has been written about the evil results after ethyl chloride anaesthesia in the dental chair is entirely imaginary.

NORMAL ACTION AND ACCOMPANYING PHONOMENA

The patient being prepared, and the gas given, as described, an administrator will notice that the first few breaths taken are of a regular quiet type. This is followed by a gradually increasing length of respiration, the breathing at the same time becoming deeper, and louder in quality. This should continue, until a distinct stertor, only to be exactly gauged by experience (described by some as midway between that produced by ether and chloroform) is reached, when the mask can be removed, and the operation commenced.

If this typical routine is followed, unconsciousness commences after twenty seconds, the average ranging from seventeen to twenty four seconds.

Full anaesthesia, I have calculated begins on an average in forty five seconds, and lasts for just over a minute, although analgesia continues for several seconds, in spite of struggling commencing. These figures are exceedingly variable, but at present I am describing the average of a typical case. Exceptions will be mentioned under the next heading.

Writers describe three stages, and I cannot do better than follow their example, and give in my own words the accompanying phonomena of ethyl chloride anaesthesia.

The first stage may be described as beginning at the commencement of administration, and lasting

till consciousness is lost. A slightly cyanosed appearance is at first noticed; breathing begins to increase in rapidity and depth; loss of consciousness is decidedly rapid, more so than under any other anaesthetic.

I have heard those who have inhaled the gas state that they experienced a general tingling in every part of the body, followed by a throbbing in the head, and buzzing in the ears. This stage only lasts twenty seconds, and passes into the second, which terminates when the patient is ready for operation. Respiration becomes decidedly quicker and deeper, the colour improving.

The eye changes here begin, the pupil gradually dilating until it becomes a considerable size, larger in my opinion than ether pupil.

Until complete anaesthesia is reached, the reaction to light is maintained, both the conjunctival and corneal reflexes being present.

An excellent test for the commencement of anaesthesia is the inability of the patient to follow with his eyes a moving hand. When the eye becomes fixed the anaesthetic stage has been reached. Twitching of the eyeball may be noticed, mystagmus is also described.

The second stage is characterised, in addition to the above, by a great increase of salivary secretion; this results in dribbling, and frothing at the mouth, and resulting swallowing.

The third stage is insensibly reached from the second, when the stertor is heard, and the operation may be commenced. The breathing is of

a very regular and deep type; the eyes are quite fixed, very generally in the downward direction. The conjunctival reflex disappears; the corneal may also be absent, but is sometimes present. The muscles throughout the body are irregular in their action. I have sometimes observed that they are in a relaxed condition; at other times general contractions are present, the hands being clenched, the masseters contracting, and finally the position of opisthotonos reached, but these phonomena will be described in the next section.

POSSIBLE ACCOMPANYING PHONOMENA - AFTER EFFECTS

Variations from the steadily increasing depth of breathing are frequent. After one or two breaths, a loud stertor may be heard, and the patient become unconscious. Previous to this the breath may have been of a choking nature, succeeded by a long inspiration, before air is again breathed into the bag. The colour in such cases is generally bad, and the length of anaesthesia short.

In contrast to this rapid production of unconsciousness, some patients may inhale the normal amount of gas, through the closed inhaler, their breathing never becoming sterterous, and unconsciousness not being reached until more c.c. of ethyl chloride have been exhibited. If more is required, care should be taken that only a small amount is given, as people go under rapidly when an extra dose is wanted, either for producing primary anaesthesia, or for re-anaesthetising.

In a few cases I have noticed that although the anaesthetic stage has been reached, the typical stertor is quite absent.

The salivary output, which is normally increased, may sometimes become excessive, that respiration is greatly interfered with. In such cases, continual swallowing may be observed, and as a rule the condition is accompanied by an unhealthy blue colour.

Frequently great excitement is manifested after a

few breaths of the gas have been inhaled, the patient often snatching the bag from the anaesthetist's hands, and hurling it to the floor.
The contractions of the masseter muscles, mentioned in the previous section, are frequently of great annoyance to the operator, especially in cases requiring operation round the mouth.
The teeth become firmly clenched, and the muscles contract spasmodically. Unless a prop has been inserted, consciousness is often reached before the mouth can be forced open, and the operation begun.
General contraction of the whole muscular system I have in several cases observed. As a result of this, the position of opisthotonos is assumed, it being necessary in the dental chair to exert considerable force, in order to keep the patient from working his way from his seat to the floor.
During anaesthesia the involuntary muscular system may be stimulated, with the resulting passages of urine and faeces; the former I have found a fairly common occurrence, the latter a rare one.
As the patient is regaining consciousness shouting and gesticulating is very common. On the whole, however, the return to consciousness is an easy one, and is at the same time rapid.
In some cases the excitement is very great. I have more than once found myself struggling on the floor with a patient who was "coming round".

Weeping and silly talk may be observed in women, pugnaciousness in men. Erotic thoughts and sensuous movements are not unknown.

And this brings me to the consideration of the after-effects, the presence or absence of which must greatly influence us in our opinion of the value of ethyl chloride, as a general anaesthetic. The most annoying after effect is undoubtedly sickness, and to this the premier place must be given. I have seen a good deal of sickness after ethyl chloride administration, but a part of it I have attributed, not so much to the drug itself, as to sympathy. In-patients in hospital I have found are rarely sick; it is among out-patients that the majority of the vomiting occurs, and among out-patients I have found it more common in dental cases than in any others.

As the patients go into a common room after having teeth removed, the first thing that many of them see is another patient vomiting, and I am convinced that through lack of preparation must be an important factor is such cases, much vomiting is of the sympathetic type. To prove my point, I have often observed that several patients have inhaled ethyl chloride without complaining of nausea, or exhibiting signs of sickness, but when once a patient has been sick, vomiting is fairly common among the remainder. Also, I have on the whole, rarely found that in-patients, and those who have been anaesthetised as out-patients, and kept

in a room by themselves afterwards, vomit after the gas. I have therefore always considered nausea and sickness a fairly frequent after effect of ethyl chloride anaesthesia, one more common after ethyl chloride administration, than after gas, but less common that after ether and chloroform exhibition, but at the same time an after effect which, with due precaution, can be greatly mitigated.

As regards statistics, it has been stated that 20 to 25% of those who have inhaled the gas have become nauseated. I think this rather too high a figure.

The nausea does not generally last for more than a quarter of an hour; if it continues for two or three hours it is exceptional, although a case is quoted in which a girl of eleven vomited for thirty hours after inhaling the gas.

To prevent vomiting, some administrators add a little nitrous oxide gas to the ethyl chloride. Acetic acid given beforehand is recommended.

Some have suggested that the entrance of a little air during the administration is valuable, but I cannot endorse this opinion.

The Tincture of Iodine in one minim doses I have found efficacious in stopping sickness caused by ethyl chloride.

For some time after they have inhaled the gas I have found that a good many patients exhibit signs of mental confusion, many complaining of headache,

and giddiness, but I do not think that these symptoms are more marked after ethyl chloride, than after the other anaesthetics, with the exception of nitrous oxide.

Coming now to the question of collapse, I have rarely seen anyone suffering from this condition from the after effects of the gas, and can only remember finding it necessary to inject strychnine and brandy in one case. Many people, on the other hand, are convinced that collapse is more common than is supposed. A full dose of the gas, from which all air has been excluded, lengthy anaesthesias, and the use of a small bag, have been stated as reasons for its occurrence.

Finally, in considering after effects, one must in addition to remembering the possibility of idiosyncrasy, which is an important factor, not forget that in deep anaesthesia, as both coughing and swallowing reflexes are abolished, the presence of any foreign body in the mouth is an exceptional danger.

DEATH FROM THE GAS, STATISTICS, AND POST-MORTEM APPEARANCES

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In 1902 Ware collected 12,436 cases of administration of ethyl chloride, amongst which only one death was recorded.

In 1903 McCardie stated that he had investigated Seitz's cases, and amongst 16,000 administrations again only one death had occurred.

In 1905 McCardie published another paper, in which he had collected seven deaths under ethyl chloride, somnoform being excluded.

In will be sufficient for our purpose to briefly mention each case.

The first one, at Innsbruck, was that of a strongly built alcoholic. Five grammes of ethyl chloride had been given; it is worthy of note that a fresh supply of the gas had tobe exhibited, as the patient was so violent.

The second case which occurred, was that of a boy of one year old, during tracheotomy for diptheria.

Five c.c. were given, and, as in the former case, a second supply of the gas was considered necessary, three c.c. being the initial dose, and two the final.

In the third case, a man of 28 was being operated on for incarcerated hernia, and had been given 15 grammes from a cone, when ether was started, and was accompanied by severe vomiting, after which the patient died. It is to be noted that in this case 15 grammes were given by means of a cone.

The fourth case was a man who had a malignant growth of the lower jaw, pressing on the larynx, to whom 6 c.c. were given, with fatal results.

In the fifth case, the subject was suffering from dropsy, and was in the last stage of heart disease, while in the sixth case, the patient could hardly open his mouth, suffering as he was from an abscess under the jaw.

The seventh case has been imperfectly reported, as the patient was left to the tender mercies of a dentist, no one else being present.

Reviewing these cases, one is at once struck with the fact that not one of these patients had any business to be given ethyl chloride at all, at any rate by the method employed, and that the condemnation of the gas, on account of such results, is a most unfair one.

A complete drunkard, with a deranged arterial system (found on post-mortem examination to have a fatty heart), a little child with diptheria, a man

with a malignant growth pressing on his larynx, a woman in the last stage of heart disease, and a man hardly able to open his mouth, a mouth partially filled with a large abscess, are hardly cases likely to do credit to any anaesthetic.
And then again observe that in the third case the gas was given by means of a cone, and fifteen grammes were required, and that in the seventh case a non-qualified man was alone present.
Further, in the first three cases, it is interesting to note that more gas was required than the initial dose, a requirement which I have before stated should be met with a most careful execution.
Taking all these circumstances into consideration, we are bound to confess that as regards safety or otherwise of the gas, these statistics teach us little or nothing. McCardie's chief comments on these cases were to the effect that the gas is dangerous when there is any swelling about the larynx, that spasm of the jaw may be coincident with spasm of the larynx; that the vapour causes increased vascularity of the mucous membrane, and finally, as we will later see, that fatty heart was found in two of the cases in the necropsy.
He gives statistics of the death rate as 1 in 10,000 cases.
In 1906, however, he published fresh statistics, stating that out of 9,711 cases, which he had investigated, there had been 4 deaths, 3 in

hospital practice out of 9,020 administrations, 1 in private out of 691, that is death rate in hospital 1 in 3,000, in private 1 in 700.
In Birmingham he stated that the death rate was 1 in 3,000 cases.
In May of 1906, Luke published later statistics, under the title "Twenty two Fatalaties, under Ethyl Chloride". This, as far as I can ascertain, is the most complete list of deaths from the gas published.
His list includes the seven cases just mentioned, and in addition fourteen others of the following nature:-

1. A thin tuberculous girl of 18, suffering from an affection of the sacro-iliac joint. The five c.c. of ethyl chloride given, was to have been followed by ether, but death occurred, before the latter could be inhaled.
2. An alcoholic woman of fifty years of age, with cellulitis of the hand and finger. Six c.c. were given in a modified Ormsby and anaesthesia quickly induced. In order to keep her under the mask was re-applied, although no more gas was added.
3. A woman of forty, while having teeth removed. After seven teeth had been extracted breathing ceased. The amount of ethyl chloride, or rather in this case somnoform, given is not stated, but it is to be presumed that as the dentist was about to attack no less than

seventeen teeth, several exhibitions would have been necessary, and ~~one~~ more than one quantity of gas had already been exhibited.

4. A boy of fourteen, while being operated on for the removal of adenoid growths; only half a minute's anaesthesia was in this case produced.
5. A woman of fifty, who had lately had two attacks of pneumonia, and who was suffering from an asthenic heart. She was anaesthetised in order to have teeth removed, but died before anything could be done.
6. A man of thirty, suffering from a malignant growth.
7. A woman of twenty, for dental extraction.
8. An alcholic woman of fifty, to whom ethyl chloride was administered for the scraping of a suppurative bursa.
9. A man of sixty seven, who died after three teeth had been extracted. Five c.c. were administered.
10. An adult man, to whom the gas was given by a dentist alone.
11. 12. 13. 14. Deaths from the gas at Leeds, Llandudno (dental case), Swansea (dental case), and Algiers.

In considering these results one will note that eight of the deaths occurred in dental cases. What can be the reason of this?

The dental chair, insufficient preparation, unsuitable subjects, unskilled administration;

any of these reasons may account for this high percentage during dental extraction.

It will be noticed that in at least one of these cases the gas was given for the purpose of producing a fairly long anaesthesia, and under these circumstances, as I said before, I do not believe that ethyl chloride is the right anaesthetic to employ.

The writer of the article from whom these results were obtained remarks on the fact that several of the cases were not suitable for any kind of anaesthetic, and that in others, chloroform was the anaesthetic indicated. In no less than seven of the cases, fatty heart was found in the necropsy. In this article Dr. Luke calculates that the deathrate from chloride of ethyl is 1 in 8,000, although he points out Lotheissen believed it to be 1 in 16,000.

In a later article he says that he believes the gas to have been administered three million times in Great Britain, and that as twenty deaths have been reported there the death rate works out at 1 in 150,000, which compares remarkably well with published statistics on death under ether and nitrous oxide, which have been stated to be 1 in 16,000 and 1 in 100,000 respectively.

Coming next to Post-Mortem appearances, as recorded above, in no less than seven of the fourteen cases in which there is a record of a post-mortem examination, the heart was found to be

in a state of fatty degeneration. We are thus at once forced to the conclusion that in such cases chloride of ethyl is of great danger.

In Lotheissen's case, atheroma of the coronary arteries was found; the blood in this case was of a cherry red colour, like blood found in carbon monoxide poisoning. All organs, with the exception of the ones actively affected, were found to be healthy in the woman of eighteen with the sarcoma ~~sacro-iliac~~, and the man with the abscess of the jaw.

In the case of the man with the malignant growth of the lower jaw, the heart, weighing twenty three ounces, was fatty, as was also the liver, while the kidneys were cirrhotic. The chief cause of death, however, was pressure on the larynx.

The woman with dropsy exhibited the symptoms of passive congestion in all her organs, and also old and recent endocarditis.

The woman with cellulitis showed pallor in all the viscera, with a thin left ventricle, and a large and fatty liver. Her stomach was dilated, and her kidneys cirrhotic.

Case number 3 revealed a heart covered with an accumulation of fat; case No. 4 nothing but a muscularly asthenic heart.

In case No. 6 malignant infiltration was found throughout the body; in case 8 a fatty heart, with nutmeg liver, and granular kidneys.

A fatty condition of the heart was also found in the 9th case, while the 10th showed an inflamed

condition of the throat and lungs. Congested lungs, and an empty heart, were observed in case 11.

INDICATIONS FOR USE

The cases in which ethyl chloride are most frequently used, as those of dental extraction, and of removal of tonsils and adenoids.

In the former, the advantage it has over gas, will be stated in the next section.

In the latter, for the removal of tonsils and adenoids, the length of anaesthesia will be found to be of the greatest value, unconsciousness lasting for a long enough period for removal of both tonsils, and thorough scraping of the posterior pharyngeal wall with the curette.

I have found the period of anaesthesia so exact for this purpose, that at the end of the operation the patient is ready at once to spit up the blood from the throat, and thus avoid the danger of choking.

Other operations in which the gas may be profitably used are, opening of abscess cavities and whitlows, difficult dressings, tenotomies, breaking down adhesions, straightening the nasal septum, ingrowing toe-nails, and vaginal examinations; in fact, in a word, any minor operation.

In all the operations mentioned I have found it in every way satisfactory, the age of the patient making slight difference, as the gas is equally well borne by young and old alike.

The contra indications for its use are undoubtedly cases in which there is oedema, and swelling round

the upper air passages. I have found little danger in giving it to several patients for the opening of an empyena, and have successfully anaesthetised an old man of 70 with the gas for this operation.

One case - a boy of 6 - to whom I administered ethyl chloride for the supposed opening of an empyema, and whom I kept under for quarter of an hour, exhibited a few days later in the post-mortem room an abscess of the liver, peritonitis, appendicitis, with a pin in the appendix, chronic gastritis, pericarditis and endocarditis.

Several experts have employed the gas in eye work, and in such cases speak of its value, one great advantage being the very slight increase of vascularity which it causes.

In 1903 the gas was employed for opthalmic work on 60 occasions. In 1904 on 91 occasions.

(Reference: Transactions of Society of Anaesthetics Vol VII. 91-118.)

It may be observed in concluding this section that ethyl chloride is exceptionally well borne by children of all ages. Hysterical patients, and alcoholics also seem to tolerate the gas better than other anaesthetics.

AS A PRELIMINARY TO OTHER ANAESTHETICS

As a preliminary to anaesthesia, ethyl chloride is now very largely employed, and in many cases has entirely taken the place of nitrous oxide.

I have been in the habit lately of always using it before giving ether, and employ the rubber and glass tube apparatus with the ordinary Clover's inhaler, an illustration of which I gave in an earlier section. After the ether bag has been blown out by the patient, I tip up the glass tube, and the ethyl chloride, running into the bag, soon produces anaesthesia. It is advisable then to turn on the ether steadily and fairly rapidly, allowing the full ether vapour to be liberated in a little over a minute. The only disadvantage of chloride of ethyl as a preliminary to ether that I have ever found has been the excess in some cases of saliva, soon after the ether has been turned on, causing repeated swallowing, until the full effect of the drug is attained. This has only occurred in a small percentage of cases, and although not alarming, is very disagreeable. The great advantage of the combination of the anaesthetics is the rapid loss of consciousness, and the absence of the unpleasant smell of the ether.

As a preliminary to chloroform, I have only rarely used ethyl chloride because I did not believe that it was efficacious, as before the patient can be got under the effects of chloroform, the anaesthesia caused by the gas has had time to work off.

Also the eye symptoms, and the breathing, being of a very different nature under these two anaesthetics it is impossible sometimes to know at what exact stage of chloroform anaesthesia the patient is.

In opposition to these remarks a paper published by Harvey Hilliard in the Medical Magazine (Feb. 1906 101-107) is of interest.

He states that he always gives a breath of ethyl chloride when vomiting from chloroform is imminent, as the anaesthesia is at once deepened, and sickness thus avoided. Further, he gives the gas as a preliminary to chloroform, in order to prevent respiratory and circulatory depression.

He states that having made repeated experiments with mixtures of ethyl chloride and chloroform, he now always employs a mixture, consisting of half a drachm of ethyl chloride, and one ounce of chloroform, instead of pure chloroform. This he generally gives on a Skinner's mask. He states that the mixture is especially valuable in severe abdominal operations and operations affecting the solar plexus, the deeper anaesthesia being of great value.

In from four to five minutes from exhibition the operation can be commenced.

The pupil is larger than the normal chloroform pupil, and thus danger can be more readily detected, changes in size being easier to observe.

Cole, of Birmingham, when he investigated the action of the gas on the heart, believing that the vagal nerve endings were paralysed by the action

of ethyl bromide, thought the continued action of somnoform and chloroform would be of great value, but as his conclusions are incorrect ~~xx kxx~~ as regards the action on the vagus, his theory is no longer tenable.

CONTRAST WITH NITROUS OXIDE, AND OTHER ANAESTHETICS

The most obvious advantage that ethyl chloride has over nitrous oxide, an advantage that will occur to anyone, is its portability.

To the General Practitioner, especially the country one, this must always be a great consideration.

The small bag, and flask containing 60 c.c. of ethyl chloride is all that is required in one case, contrasting strongly with the heavy cylinders, tubing and bag, required for nitrous oxide administration. Some have even done away with the bag, and have only carried the flask, inducing anaesthesia by squirting the gas on to cotton wool, inserted between the cheeks and teeth.

To many, the considerably smaller price of chloride of ethyl will turn the balance in its favour, the two shilling flask allowing no less than between twelve and eighteen administrations.

When we come to the more scientific side of the question, one is bound to confess that nitrous oxide has the distinct advantage as regards safety, and to many, this will be final. Such people constitute the school which will, under no cirumstances, look at ethyl chloride, and are to be condemned for what I think we must all allow, is an unreasonable timidity.

Chloride of ethyl is an easy anaesthetic to take; it produces unconsciousness in an easy and agreeable manner, not causing the cyanosed condition

always reached after nitrous oxide has been inhaled. It is an easy anaesthetic to give, the rapidity of "going under", "keeping under", and "coming out", all contrasting favourably with nitrous oxide, although the latter is to be preferred for the avoidance of sickness, headache and general discomfort.

As regards comparison between ethyl chloride, ether and chloroform, I do not think such is necessary, as I do not consider they are in the same category.

Ethyl chloride should be used for short operations, when a longer and deeper anaesthesia than that afforded by nitrous oxide is required, and can only take the place of ether and chloroform under such circumstances, but for longer operations, such as we are in the habit of employing the others for, I do not consider that ethyl chloride should be used at all, as the patient must run a greater risk, to no possible advantage.

As regards the toxicity of the various anaesthetics, it is interesting to note that toxicity depends upon the carbon radical, the anaesthetic with the carbon radical being more toxic than the one without; chloroform, therefore, is more toxic than nitrous oxide. Further, the halogen with the organic radical shows a greater toxicity, increasing directly with the number of halogen elements in the molecule; chloroform, therefore, is more toxic than ethyl chloride.

(Reference: Proceedings of Royal Society, London,

1905-6. LXXVII. 86-102).

In conclusion, it will be easily seen from the perusal of this thesis what my position is, as regards ethyl chloride. I am a member of the moderate school, believing that the gas is a most useful one, and should be freely, but in no way recklessly, used; that on account of results obtained there is little to be said for those who are afraid of it; that on account of its physiological action there is equally little to be said for those who abuse it.

Much has been written about it; by most people little is known of it; a routine use in hospital being all the claim that many possess of knowledge regarding it. That such a drug should be allowed to sink into oblivion after its long struggle to come to the front, because of the condemnation of the ignorant who have never tried it, would be a grave, but an unlikely, contingency, for those who have studied the utility of it with any care will for their own advantage strive to give it the position it deserves.

T H E E N D